Air Pollution and its potential climate effect in Delhi, India

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Delhi, the capital city of India with more than 10 million population, is suffering one of the worst particulate matter (or PM2.5) pollution over the world. Based on continuous observations during 2015-2018, we report that the PM2.5 pollution in Delhi is possibly one of the worst within Indian cities, and responsible for \( \sim 10,000 \) premature deaths of cities per year. Especially during the Diwali Fest, the hourly PM2.5 concentrations went above 1600 ug/m\(^3\), leading to \( \sim 20 \) extra premature deaths per day (Chen et al., 2019). We find a distinct seasonal variation of PM2.5 mass concentrations and a shift of morning rush hour from winter to summer, but a negligible weekend effect in Delhi. We also report a long-term result of hygroscopicity of PM2.5 in Delhi is about \( \kappa = 0.42 \pm 0.07 \) for the first time, indicating much higher potential of cloud droplet activation from fine particles in Delhi compared with other Asian megacities, such as Beijing (\( \kappa = 0.14-0.23 \)) (Wang and Chen, 2019). It means, in addition to the great health burden, more significant cloud activation and greater influences on climate and hydrologic cycle are expected from fine particles in Delhi.

Method & Data

We analysed the PM2.5 observations from US Embassy in Delhi, and used the Integrated Exposure Response Function to estimate the long-term and short-term health effect of PM2.5 exposure with a particular focus on the Diwali Fest period. Together with the temperature, RH and visibility data from the DEL airport in Delhi, we retrieved the 2016-2018 averaged hygroscopicity (\( \kappa \)) in Delhi according to the \( \kappa \)-kJ\( \ddagger \)shler and Mie theories. In summary, we firstly retrieve the optical enhancement from visibility and RH, and then retrieve the optical-\( \kappa \), and finally estimate the \( \kappa \) from the optical-\( \kappa \). The detailed retrieving method is given in Wang and Chen (2019), this method has been validated in Beijing within an uncertainty of 30%.
Summary

Our results show a strong seasonal variation of PM2.5 in Delhi, with severest pollution during the winter. The Diwali and New Year Fests also lead to extreme pollution events, i.e. worse than the ‘Severe’ Level, in the beginning of November and January. These lead to adverse health effect and make Delhi the top-1 health burden city in India. The long-term averaged hygroscopicity of PM2.5 in Delhi is much higher than Beijing and Asian average. This indicate much easier for fine particles serving as cloud condensation nuclei and contributing the climate change and hydrology cycle. Moreover, the high optical enhance factor, f(RH), implies strong direct radiative forcing enhancement and influences on the heterogeneous reactions in Delhi.

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References:
